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# Are within-individual causes of delinquency the same as between-individual causes?

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## ABSTRACT

**Background** *Previous studies of the causes of delinquency have been based on between-individual correlations. This paper aims to study the causes of delinquency by comparing within-individual and between-individual correlations of risk factors with delinquency.*

**Method** *A total of 506 boys in the oldest sample of the Pittsburgh Youth Study were followed up in seven data waves between ages 13.8 and 17.8 on average.*

**Results** *Poor parental supervision, low parental reinforcement and low involvement of the boy in family activities were the most important causes of delinquency according to forward-lagged within-individual correlations. Poor housing was positively related to delinquency for boys living in bad neighbourhoods but not for boys living in good neighbourhoods.*

**Conclusions** *Forward-lagged within-individual correlations provide more valid information about the causes of delinquency than do between-individual correlations. Peer delinquency was the strongest correlate of delinquency according to between-individual correlations but was not a cause of delinquency according to forward-lagged within-individual correlations.*

## Introduction

It is crucially important to establish the causes of delinquency, in order not only to explain delinquency but also to prevent and treat it successfully. This paper investigates causation using a new method in criminology. Since the influential research of Glueck and Glueck (1950), almost all studies of the causes of delinquency have compared risk factors of delinquents and non-delinquents or have correlated risk factors with levels of delinquency. In both

cases, between-individual differences in risk factors are compared with between-individual differences in delinquency.

There is, however, another way to investigate the causes of delinquency, by comparing within-individual changes in risk factors over time with within-individual changes in delinquency over time. This method has rarely been used, because it requires repeated measures of both risk factors and delinquency in a longitudinal study. Nevertheless, it is arguably a better way of studying causes. In order to advance knowledge about these two different methods of studying the causes of delinquency, this paper compares – for the first time in criminology as far as we are aware – between-individual and within-individual correlations between risk factors and delinquency. Because of their novelty, these analyses are mainly illustrative.

The concept of cause fundamentally refers to the concept of change within individual units. A risk factor *X* causes an outcome *Y* if, with some specified degree of regularity, changes in *X* are followed by changes in *Y*. For example, the death of a father may cause a decrease in the economic status of his family. As this example shows, the variables *X* and *Y* can be dichotomous (father living or dead), continuous (family economic status) or of some other kind (e.g. with four categories).

The unit does not have to be an individual person (e.g. it could be a family), but this paper is concerned with changes within individual persons. This paper is particularly concerned with relating changes in possible causes of delinquency (e.g. low achievement, poor parental supervision, poor housing) to changes in delinquency. ‘Within-individual’ in this context does not refer solely to factors inside the individual (e.g. personality features) but to changes over time in variables applying to the individual; thus, to the extent that an individual’s poor supervision and poor housing change over time, these are considered to be within-individual changes.

As mentioned, causes are usually inferred from variations between individuals rather than from changes within individuals. For example, a study might demonstrate that males were more likely than females to be delinquents, and that this relationship between gender and delinquency held up after controlling statistically for some other presumed causes of delinquency. It might then be concluded that gender was a cause of delinquency. However, drawing conclusions about causes, or in other words about the effect of changes within individuals, on the basis of variations between individuals, involves a conceptual leap that may not be justifiable. Since it is arguably impossible to change males into females (or vice versa), it is arguably unreasonable to consider gender as a possible cause of delinquency (Farrington, 1988).

In studies of variations between individuals, it is very difficult to disentangle the effect of the risk factor of interest (e.g. unemployment) from the effects of numerous other risk factors that are correlated with unemployment and that might influence delinquency. For example, compared with employed people, unemployed people may be more impulsive, less intelligent, more

unskilled, heavier drinkers and living in poorer housing even before they were unemployed. In studies of changes within individuals, all these pre-existing differences between individuals are controlled (held constant), making it far more possible to isolate the effect of unemployment on delinquency as an individual changes from being employed to being unemployed (and back again).

Traditionally in criminology, a variable has been regarded as a cause if it is correlated with delinquency, if it occurs before delinquency, and if the relationship between the variable and delinquency holds up after controlling for other possible confounding variables that might be causes. These criteria make it possible to study the causes of delinquency in cross-sectional surveys (e.g. Hirschi, 1969), although it is often difficult to establish causal order in such surveys. However, these criteria of causation are unconvincing.

Ideally, the causes of delinquency could be demonstrated most convincingly in controlled experiments in which individuals were randomly allocated to change from (e.g.) being employed to being unemployed, from being unemployed to being employed, or to a control group. Manipulating the independent variable within or between individuals may have different effects (Erlebacher, 1977). However, studying the causes of delinquency using these kinds of experiments is rarely feasible. It is more practicable to study causes in experiments designed to prevent or treat delinquency (Robins, 1992). For example, unemployed young people could be randomly assigned to an employment programme or to a control group and the effects on delinquency could be investigated.

In practice, however, prevention and treatment experiments are usually multi-modal, including several different interventions rather than simply targeting one risk factor such as unemployment. This makes it difficult to identify the 'active ingredient' and to draw conclusions about causes from such experiments. Because prevention and treatment experiments can only be targeted on factors that can change within individuals, it might be argued that conclusions about causes based on variations between individuals may have no or at least questionable implications for prevention or treatment.

Because of the problems of carrying out controlled experiments targeting only one risk factor, the causes of delinquency can be demonstrated most convincingly in within-individual quasi-experimental analyses in longitudinal surveys in which individuals are followed up before and after some presumed cause. For example, in the Cambridge Study in Delinquent Development, Farrington (1977) found that self-reported delinquency increased after a boy was first convicted (compared with unconvicted boys), in agreement with the theory that official labelling caused increased delinquency. Farrington et al. (1986) showed that convictions increased during periods of unemployment compared with periods of employment, in agreement with the theory that unemployment caused crime. Farrington and West (1995) demonstrated that a man's convictions decreased after marriage and increased after separation

from his wife, again suggesting some causal influences of both marriage and separation on offending.

The main aim of this paper is to shed further light on the causes of delinquency by investigating whether within-individual correlations of risk factors with delinquency are similar to or different from between-individual correlations of risk factors with delinquency. Because pre-existing extraneous influences on delinquency are confounded in between-individual correlations but controlled in within-individual correlations, it is to be expected that between-individual correlations will be (misleadingly) greater. If a between-individual correlation is substantial and the corresponding within-individual correlation is negligible, this would suggest that the risk factor is not a cause of delinquency and is only correlated with delinquency because it is confounded with other causal factors.

This paper also compares results obtained with simultaneous correlations (where the risk factor and delinquency are measured at the same time) with forward-lagged correlations (where the risk factor is measured before the delinquency). Arguably, forward-lagged correlations throw more light on causes. The paper also investigates individual differences in within-individual correlations with delinquency: whether certain types of people in certain contexts have positive correlations between risk factors and delinquency while other persons have negative or zero correlations. Finally, the paper compares the predictive accuracy of composite risk scores based on between-individual correlations with risk scores based on within-individual correlations.

## Method

Within-individual correlations of risk factors with delinquency can only be investigated in longitudinal surveys. This analysis requires repeated measures of delinquency and of presumed causal factors. This paper is based on analyses of the oldest sample of the Pittsburgh Youth Study, comprising 506 boys assessed in the first follow-up wave (A) at an average age of 13.8 (Loeber et al., 1998). Seven waves of data are analysed, covering ages 13.8 to 17.8 on average. Table 1 shows that the number of boys known on delinquency decreased from 506 in wave A to 421 in wave I (83.2%). In waves A–E, questions were asked about the previous six months, whereas in waves G and I questions were asked about the previous 12 months. The change in the reference period from 6 to 12 months is not too serious because the main focus of the analyses is on correlations rather than on mean scores. Similarly, unweighted data are used because of the focus on correlations rather than mean scores.

*Delinquency* was measured according to self-reports of the frequency of committing the following 25 types of acts in the specified time period: carrying a weapon; vandalism; firesetting; avoiding paying (e.g. for a fare); breaking and entering; stealing an item worth less than US\$5; stealing an item worth

\$5–\$50; stealing an item worth \$50–\$100; stealing an item worth more than \$100; shoplifting; pickpocketing; stealing from a car; handling stolen goods; joyriding; vehicle theft; cheque fraud; credit card fraud; cheating someone out of money; attacking to hurt; robbery or strongarming; gang fighting; hurting someone to get sex; forcing someone to have sex; selling marijuana; and selling heroin, cocaine or LSD.

Table 1 shows that the prevalence of delinquency (committing at least one act) stayed tolerably constant, if anything decreasing from wave B (45.2%) to wave D (36.9%) and then increasing up to wave I (48.2%). In contrast, the individual offending frequency increased steadily, from 15.7 offences per offender in wave A to 150.7 offences per offender in wave I. There was no sign of any obvious discontinuity between wave E (based on six months) and wave G (based on 12 months). Other researchers have also found that frequency estimates in the previous year are similar to frequency estimates in the previous few months (Bachman and O'Malley, 1981).

In choosing factors to correlate with delinquency, we began with the 40 key explanatory variables identified at wave A by Loeber et al. (1998). The data reduction process ensured that these variables were not highly intercorrelated. It was not possible to calculate within-individual correlations with delinquency for most of these variables, because they were either dichotomous or had very few values (see Farrington and Loeber, 2000) or were not measured comparably in all seven waves. Only nine explanatory variables were measured comparably using a reasonably continuous scale. Peer delinquency was therefore added as a tenth variable; it was considered by Loeber et al. (1998, p. 107) to be a correlate rather than a cause of delinquency, since about three-quarters of delinquent acts were committed with peers.

The 10 variables are as follows:

- (1) *HIA problems*: number of hyperactivity, impulsivity or attention deficit problems out of 14, rated by mothers and teachers.
- (2) *Low academic achievement*: a continuous score from 1.0 (above average) to 4.0 (failing), rated by boys, mothers and teachers.
- (3) *Depressed mood*: a score from 0 to 11, based on 11 items rated by mothers and teachers (e.g. about whether the boy is lonely, cries a lot, feels that no one loves him, feels worthless, is unhappy, worries a lot).
- (4) *Poor parental supervision*: a score from 8 to 24 based on four questions to the boy and four questions to the mother (e.g. 'Do your parent(s) know who you are with when you are away from home?').
- (5) *Low parental reinforcement*: a score from 14 to 42 based on seven questions to the boy and eight questions to the mother, about how often the boy is praised or otherwise reinforced.
- (6) *Poor parent–boy communication*: a score from 58 to 174 based on 29 questions to the boy and 30 questions to the mother (e.g. 'Do you tell your mother/father about your personal problems?').

- (7) *Low involvement of the boy in family activities*: a score from 8 to 24 based on four questions to the boy and four questions to the mother, about how often he is involved in planning family activities or joining family members on outings.
- (8) *Low socio-economic status (SES)*: the Hollinghead index, scored from 0 to 60, derived by multiplying the scale value for occupational prestige (from none to executive/professional) by 5 and the scale value for the educational level of the parent (from sixth grade or less to advanced degree) by 3, based on information from the mother. If there were two parents, the better SES score was selected.
- (9) *Poor housing*: a score from 0 to 16, based on eight items completed by the interviewer covering the structural condition of the house, visible signs of peeling paint and plaster, and cleanliness inside the house.
- (10) *Peer delinquency*: a score from 0 to 32, based on the proportion of friends who engage in eight different types of delinquency, according to the boy's report. The eight types of delinquency were: vandalism; stealing an item worth \$5–\$100; stealing an item worth more than \$100; joyriding; attacking to hurt; hitting to hurt; strongarming or robbery; and truancy. The score on each item varied from 0 (none of them) to 4 (all of them).

All variables were scored so that high scores were undesirable, e.g. reflecting low achievement, poor parental supervision, low reinforcement, and so on. With the exception of poor housing, all variables referred to the same time period as delinquency (i.e. the last six months in waves A–E and the last 12 months in waves G and I). Poor housing referred to the current situation.

Most variables were positively intercorrelated, but no intercorrelation in wave A was greater than 0.50. Spearman rank correlations are used throughout this paper because many of the frequency distributions (and especially delinquency) were skewed. The highest intercorrelations in wave A were between HIA problems and depressed mood ( $r = 0.50$ ), poor parental supervision and poor parent-boy communication ( $r = 0.48$ ), low parental reinforcement and poor parent-boy communication ( $r = 0.47$ ), HIA problems and low achievement ( $r = 0.41$ ), and poor parent-boy communication and low involvement of the boy in family activities ( $r = 0.40$ ).

Table 1 shows the mean score on each variable in each wave. HIA problems, depressed mood, low SES and poor housing generally decreased over time, while poor supervision, low reinforcement, low involvement of the boy in family activities, peer delinquency and of course the boy's delinquency increased. Low achievement and poor parent-boy communication stayed tolerably constant (see also Loeber et al., 2000).

The mean stability correlations from each wave to the next were also calculated. Low SES ( $r = 0.78$ ) and poor parent-boy communication ( $r = 0.73$ ) were most stable over time, whereas poor housing ( $r = 0.35$ ) was least stable. This low stability may possibly reflect the unreliability of ratings of housing by

Table 1: Mean scores in each wave

Wave	A	B	C	D	E	G	I	Mean stability correlation
Mean age	13.8	14.3	14.8	15.3	15.8	16.8	17.8	–
No. of boys Known*	506	480	460	458	449	433	421	–
Percent delinquent	43.0	45.2	37.6	36.9	41.0	42.0	48.2	–
Mean indiv. frequency	15.7	28.0	23.7	36.9	70.2	97.5	150.7	–
Mean scores								
Delinquency	6.8	12.6	8.9	13.6	28.8	40.9	72.6	0.512
HIA problems	8.6	8.3	8.2	8.0	7.5	6.9	6.6	0.517
Low achievement	2.2	2.3	2.2	2.3	2.3	2.3	2.2	0.600
Depressed mood	2.7	2.6	2.3	1.9	1.6	1.7	1.8	0.572
Poor supervision	11.9	11.8	12.0	12.0	12.3	12.6	13.2	0.655
Low reinforcement	23.5	22.9	23.2	23.8	24.0	24.1	24.5	0.584
Poor communication	95.0	93.3	92.7	94.2	93.8	93.7	93.9	0.732
Low involvement	15.0	15.0	15.5	15.9	16.5	17.1	17.4	0.657
Low SES	29.4	29.9	29.8	29.3	29.1	28.5	27.7	0.784
Poor housing	2.6	2.3	2.6	1.7	2.0	1.9	1.5	0.354
Peer delinquency	4.6	4.4	4.4	4.7	4.8	5.1	5.6	0.581
<i>Notes:</i> HIA = hyperactivity-impulsivity-attention deficit; SES = socio-economic status; mean stability based on Spearman correlations; * on delinquency; indiv. frequency = no. of offences per offender								

different interviewers. The mean stability of the delinquency score (number of acts committed per boy) was 0.51.

## Results

### *Within-individual vs. between individual correlations*

Table 2 shows the mean between-individual and within-individual correlations with the delinquency score. The between-individual correlations were calculated for each wave (based on 400–500 boys) and then averaged over seven waves. The within-individual correlations were calculated for each boy (based on seven waves) and then averaged over the 370–380 boys who admitted at least one delinquent act.

The  $p$  values were calculated by relating the mean correlation to the standard error of the mean. For example, the mean between-individual  $r$  was 0.199 and its standard error was 0.019. The calculation of the standard error of the mean was based on the assumption of underlying bivariate normal distributions. However, the central limit theorem specifies that sampling distributions



Table 2: Mean correlations with delinquency				
Variables	Between-individual		Within-individual	
	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
HIA problems	0.188	0.001	−0.024	ns
Low achievement	0.139	0.001	0.031	ns
Depressed mood	0.149	0.001	0.017	ns
Poor supervision	0.245	0.001	0.141	0.001
Low reinforcement	0.092	0.001	0.037	ns
Poor communication	0.211	0.001	0.066	0.005
Low involvement	0.226	0.001	0.102	0.001
Low SES	0.079	0.008	−0.043	ns
Poor housing	0.150	0.001	0.040	ns
Peer delinquency	0.513	0.001	0.287	0.001
Mean	0.199	0.001	0.067	0.001
Notes: <i>r</i> = Spearman correlation; averaged over seven waves; ns = not significant.				

based on large *n* (as here) are approximately normal even if underlying distributions are not normal.

Another assumption underlying the calculation of the standard error of the mean is that the pairs of observations being correlated are independent. Here, each between-individual correlation was based on independent pairs of observations, but the mean correlations that were then averaged were not independent (since each was based on the same 400–500 boys). Conversely, each within-individual correlation was not based on independent pairs of observations, but the resulting correlations (one per boy) that were averaged were independent. The combination of independent and dependent observations was similar for between-individual and within-individual mean correlations, and so it does not affect their comparability.

All 10 variables were significantly correlated with delinquency between individuals. Peer delinquency was most strongly correlated (*r* = 0.51) and low SES least strongly correlated (*r* = 0.08). Poor parental supervision (*r* = 0.25) low involvement in family activities (*r* = 0.23) and poor parent–boy communication (*r* = 0.21) were also strong correlates of delinquency between individuals. The mean *r* was 0.20, and this did not vary markedly over time. Similarly, the correlation between each variable and delinquency did not clearly increase or decrease over time.

As expected, the within-individual correlations with delinquency were lower than the between-individual correlations. Only four variables were significantly correlated with delinquency within individuals: peer delinquency (*r* = 0.29), poor supervision (*r* = 0.14), low involvement in family activities (*r* = 0.10) and poor parent–boy communication (*r* = 0.07). The mean within-individual correlation was 0.07.

It might be argued that the correlations in Table 2 provide a poor basis for causal inference because each variable and delinquency were measured at the same time and usually refer to the same reference period. The concept of cause involves time ordering: changes in presumed causes of delinquency occur *before* changes in delinquency. Therefore, it might be better to study forward-lagged correlations, where each variable is measured in wave ( $n$ ) and delinquency is measured in wave ( $n + 1$ ). The major problem with this is that the true causal lag is unknown. After what time interval might a change in parental supervision cause a change in delinquency? This effect seems unlikely to occur instantaneously, but seems more likely to occur gradually over a period of several months. Therefore, arguably, the forward-lagged correlations provide a better test of causal relationships than the simultaneous correlations.

Table 3 first shows the forward-lagged correlations between individuals. Each correlation is calculated by comparing a variable in wave ( $n$ ) with delinquency in wave ( $n + 1$ ) over all boys. The mean correlation is based on six of these correlations. The mean  $r$  of 0.18 was rather similar to the mean  $r$  of 0.20 for simultaneous correlations between individuals. Except for peer delinquency, every forward-lagged correlation was within 0.025 of the simultaneous correlation. The forward-lagged correlation for peer delinquency ( $r = 0.39$ ) was much lower than the simultaneous correlation ( $r = 0.51$ ).

Table 3 next shows the forward-lagged correlations within individuals. The correlation for each boy is based on only six comparisons of a variable in wave ( $n$ ) and delinquency in wave ( $n + 1$ ), and the mean correlation is the average

Table 3: Lagged correlations with delinquency

Variables	Variables predicting delinquency				Delinquency predicting variables			
	Between		Within		Between		Within	
	$r$	$p$	$r$	$p$	$r$	$p$	$r$	$p$
HIA problems	0.212	0.001	-0.002	ns	0.190	0.001	-0.007	ns
Low achievement	0.145	0.001	0.044	ns	0.125	0.001	0.020	ns
Depressed mood	0.125	0.002	-0.013	ns	0.144	0.001	-0.065	0.023
Poor supervision	0.222	0.001	0.081	0.005	0.230	0.001	0.044	ns
Low reinforcement	0.115	0.001	0.070	0.019	0.093	0.006	0.023	ns
Poor communication	0.193	0.001	0.041	ns	0.178	0.001	0.012	ns
Low involvement	0.214	0.001	0.121	0.001	0.215	0.001	0.035	ns
Low SES	0.097	0.004	0.013	ns	0.089	0.011	0.006	ns
Poor housing	0.125	0.007	0.024	ns	0.134	0.002	0.039	ns
Peer delinquency	0.393	0.001	0.044	ns	0.104	0.001	0.042	ns
Mean	0.184	0.001	0.042	0.009	0.150	0.001	0.015	ns

Notes:  $r$  = Spearman correlation; averaged over six comparisons of wave ( $n$ ) and wave ( $n + 1$ ); ns = not significant.

$r$  over all boys. The mean correlation was low ( $r = 0.04$ ). Only three variables had significant forward-lagged correlations: low involvement of the boy in family activities ( $r = 0.12$ ), poor parental supervision ( $r = 0.08$ ) and low reinforcement ( $r = 0.07$ ). The forward-lagged correlation for peer delinquency ( $r = 0.04$ ) was dramatically less than the simultaneous correlation within individuals ( $r = 0.29$ ).

It is also possible to study backward-lagged correlations comparing delinquency in wave ( $n$ ) with each variable in wave ( $n + 1$ ). Arguably, these indicate how far changes in delinquency might cause changes in a variable. Table 3 shows that all the backward-lagged correlations between individuals were statistically significant. The mean backward-lagged correlation of 0.15 was lower than the mean forward-lagged correlation of 0.18 because of the dramatic decrease in the correlation for peer delinquency: from 0.39 (forward-lagged) to 0.10 (backward-lagged). All other backward-lagged correlations were within 0.025 of the corresponding forward-lagged correlation.

Finally, Table 3 shows backward-lagged correlations within individuals. Arguably, if the forward-lagged within-individual correlation of a variable with delinquency is significant and positive while the corresponding backward-lagged within-individual correlation is zero, this is evidence that the variable is a cause of delinquency. Also, if both forward-lagged and backward-lagged within-individual correlations are significant and positive, this might be evidence of reciprocal causation. These backward-lagged correlations were all non-significant, with one exception. Delinquency in wave ( $n$ ) was negatively correlated with depressed mood in wave ( $n + 1$ ). Unexpectedly, high delinquency scores in one wave were associated with low depression scores in the next. However, the correlation was not high ( $r = -0.07$ ).

It would have been possible to correlate change scores, for example comparing the change in a variable between wave ( $n$ ) and wave ( $n + 1$ ) with the change in delinquency between wave ( $n$ ) and wave ( $n + 1$ ). However, change scores have high variability, and the number of waves is small. Also, conventional regression equations (where  $Y$  is some function of  $X_1, X_2, X_3$ , etc.) can easily be rewritten as regression equations based on change scores (Kessler and Greenberg, 1981). Therefore, our correlations arguably provide information about how far changes in a variable are related to changes in delinquency.

#### *Further analyses of within-individual correlations*

In the within-individual analyses, each boy has his own correlation between each variable and delinquency. Some boys may have high positive correlations between a variable (e.g. poor parental supervision) and delinquency, while others have high negative correlations. To the best of our knowledge, this is the first study presenting within-individual correlations in criminology, but within-individual correlations have been presented in other fields (e.g. Verthein and Kohler, 1997; Janssen et al., 1998). Of course, since these with-

in-individual correlations are based on only seven waves of data (pairs of observations), they are likely to fluctuate considerably.

Table 4 classifies these correlations as positive (greater than 0.3), negative (less than  $-0.3$ ) or low (between  $-0.3$  and  $+0.3$ ). For example, poor parental supervision was positively correlated with delinquency for 148 boys (40%), negatively correlated for 68 boys (18%) and had a low correlation for 158 boys (42%). The ratio of positive to negative correlations (here, 2.2) is used as an index of whether the variable was positively or negatively related to delinquency within individuals. The significance of this ratio is tested by comparing it with the null hypothesis that 50% of correlations will be positive and 50% negative (of those that are not low). For parental supervision, this test yielded a chi-squared value of 29.6 ( $p < 0.001$ ).

For the simultaneous correlations with delinquency, the number of positive correlations was significantly greater than the number of negative correlations for only four variables: poor parental supervision, poor parent–boy communication, low involvement of the boy in family activities, and peer delinquency. This replicates the results obtained with mean within-individual correlations in Table 2.

Table 4 also shows results obtained with forward-lagged within-individual correlations comparing the variable in wave ( $n$ ) with delinquency in wave ( $n + 1$ ). The number of positive correlations was significantly greater than the number of negative correlations for only three variables: poor parental supervision, low parental reinforcement and low involvement of the boy in family activities. This replicates the results obtained with mean forward lagged correlations in Table 3.

Table 4: Individual differences in within-individual correlations

	Simultaneous				Forward-lagged			
	% Neg	% Low	% Pos	+/- Ratio	% Neg	% Low	% Pos	+/- Ratio
HIA problems	29	46	24	0.8	30	38	33	1.1
Low achievement	27	42	31	1.1	29	38	34	1.2
Depressed mood	29	40	30	1.0	33	38	29	0.9
Poor supervision	18	42	40	2.2*	29	32	39	1.4*
Low reinforcement	28	39	33	1.2	28	34	39	1.4*
Poor communication	22	46	32	1.4*	30	34	36	1.2
Low involvement	23	38	39	1.7*	22	39	39	1.8*
Low SES	31	43	25	0.8	32	34	33	1.0
Poor housing	29	38	33	1.1	33	36	31	0.9
Peer delinquency	11	30	59	5.1*	26	41	33	1.3

Notes: Spearman correlations; forward-lagged = variable in wave ( $n$ ) versus delinquency in wave ( $n + 1$ ); Neg = negative correlation  $> -0.3$ ; Low = correlation between  $-0.3$  and  $+0.3$ ; Pos = positive correlation  $> +0.3$ ; \* = significantly ( $p < 0.05$ ) different from 1.0.

It is possible to investigate whether certain categories of boys tend to have positive within-individual correlations between (e.g.) poor parental supervision and delinquency, whereas other categories tend to have low or negative correlations. As an illustration, do boys living in good or bad neighbourhoods differ in these correlations? The rating of good or bad neighbourhood was based on 1990 census data on family income, the number of single-parent female-headed households, and the percentage of persons aged 10–14.

Whether a boy had a positive, low or negative (simultaneous) correlation between each variable and delinquency was related to good or bad neighbourhood. Table 5 shows that the relationship between poor housing and delinquency differed significantly (chi-squared = 6.09, 2 d.f.,  $p = 0.047$ ) according to neighbourhood. In bad neighbourhoods, poor housing tended to be positively rather than negatively correlated with delinquency, whereas there was no relationship between poor housing and delinquency in good neighbourhoods. This was the only significant result.

Forward-lagged within-individual correlations, in which a variable in wave ( $n$ ) was correlated with delinquency in wave ( $n+1$ ), were also investigated. Replicating the result for simultaneous correlations, the relationship between poor housing and delinquency differed according to neighbourhood (chi-squared = 5.90, 2 d.f.,  $p = 0.052$ ). Poor housing was positively rather than negatively correlated with delinquency in bad neighbourhoods (49% versus 29%: chi-squared = 6.26, 1 d.f.,  $p = 0.012$ ) but not in good neighbourhoods.

*Between-individual vs. within-individual risk scores*

Risk scores are typically based on between-individual correlations. For example, a between-individual risk score was calculated based on the five variables

Table 5: Within-individual correlations between poor housing and delinquency				
	% Neg	% Low	% Pos	+/- Ratio
Simultaneous				
Good neighbourhood	33	33	33	1.0
Bad neighbourhood	23	47	30	1.3
Forward-lagged				
Good neighbourhood	33	40	28	0.9
Bad neighbourhood	29	22	49	1.7*
Notes: Spearman correlations; forward-lagged = variable in wave ( $n$ ) versus delinquency in wave ( $n + 1$ ); Neg = negative correlation $> -0.3$ ; Low = correlation between $-0.3$ and $+0.3$ ; Pos = positive correlation $> +0.3$ ; * = significantly ( $p < 0.05$ ) different from 1.0.				

In a second prediction exercise, a risk score was developed in each wave A–G and used to predict delinquency in the next wave B–I. The between-individual risk score in each wave was based on the same five variables with the highest between-individual correlations as before. The average correlation

Prediction	$r$	1	2	3	4	5
(a) Wave K						
Between score	0.255	29	35	49	45	60
Within score	0.163	44	52	56	53	61
(b) Next wave						
Between score	0.265	21	23	35	41	48
Within score	0.051	28	35	33	35	35

Notes:  $r$  = Spearman correlation; 1 = 0–20 percentile; 2 = 20–40 percentile; 3 = 40–60 percentile; 4 = 60–80 percentile; 5 = 80–100 percentile

between this risk score in one wave and the frequency of delinquency in the next wave was 0.27 ( $p < 0.001$ ; averaged over six prediction exercises). The average percentage delinquent increased from 21% of those with the lowest scores (0–20) to 48% of those with the highest scores (80–100). The average area under the ROC curve was 0.64.

The within-individual risk score in each wave was based on the five variables for each boy that had the highest within-individual correlations with delinquency over the seven waves A–I. The average correlation between this risk score in one wave and the frequency of delinquency in the next wave was only 0.05 ( $p = 0.013$ ; averaged over six prediction exercises). The average percentage delinquent increased only slightly, from 28% of those with the lowest scores to 35% of those with the highest scores. The average area under the ROC curve was 0.53.

It might be argued that these within-individual risk scores are poorer predictors because both of these exercises essentially involve a between-individual criterion of predictive accuracy. As a final test, within-individual correlations were calculated between risk scores and the frequency of delinquency across waves A–I. The mean correlation (averaging over all boys) for the within-individual risk score was much higher ( $r = 0.46$ ,  $p < 0.001$ ) than for the between-individual risk score ( $r = 0.15$ ,  $p < 0.001$ ). This suggests that a within-individual risk score can be a stronger predictor of delinquency if a within-individual criterion of predictive accuracy is used.

## Conclusions

Arguably, the most convincing information about causes of delinquency is based on forward-lagged within-individual correlations. Only three variables were significantly related to delinquency according to these correlations: poor parental supervision, low parental reinforcement, and the boy's low involvement in family activities. Out of the 10 variables studied here, these three variables seem most likely to be causes of delinquency. The backward-lagged within-individual correlations indicated that delinquency did not cause poor supervision, low reinforcement or low involvement.

Peer delinquency was the strongest correlate of delinquency according to between-individual correlations. However, it was not related to delinquency according to forward-lagged within-individual correlations. This suggests that peer delinquency is not a cause of delinquency. Arguably, it measures the same underlying construct as delinquency itself. If a boy commits delinquent acts, he is very likely to have delinquent friends, because most of his delinquent acts are committed with other boys of about the same age.

Different categories of boys had different types of relationships between risk factors and delinquency. In both simultaneous and forward-lagged correlations, poor housing was positively correlated with delinquency for boys living

in bad neighbourhoods but not for boys living in good neighbourhoods. These results suggest that poor housing might cause delinquency only for boys living in bad neighbourhoods.

Generally, between-individual risk scores were better predictors of delinquency than were within-individual risk scores. However, a within-individual risk score was a stronger predictor of delinquency when a within-individual criterion of predictive accuracy was used.

These analyses, of course, have certain limitations. In particular, it would be better to calculate within-individual correlations based on more data waves than seven. Also, we have not yet attempted to carry out multivariate analyses investigating how far relationships between one variable and delinquency hold up after controlling for relationships between other variables and delinquency. Such analyses are more straightforward for between-individual correlations than for within-individual correlations. It may be, for example, that only one or two of the three family variables of supervision, reinforcement and involvement are independently predictive of delinquency within individuals. It may be that within-individual and between-individual variation could be partitioned in some kind of hierarchical linear modelling analysis (Bryk and Raudenbush, 1987).

As mentioned, our analyses in this paper are illustrative rather than definitive. There have been very few previous attempts to study the causes of delinquency based on within-individual data, and none that compare between-individual and within-individual correlations. This is partly because the necessary data – with repeated comparable measures of risk factors and delinquency in several data waves – have not been available until recently. Now that prospective longitudinal surveys are collecting more frequent data waves, we look forward to seeing more analyses in the future based on within-individual data. We believe that these analyses will provide more valid information both about the causes of delinquency and about the risk factors that should be targeted in prevention and treatment interventions. Also, to the extent that within-individual analyses show that the causes of delinquency are different for different categories of people, these analyses might indicate how far different types of interventions should be individually tailored to different types of people.

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